



## First record of the invasive Brown Anole, *Anolis sagrei* Duméril & Bibron, 1837 (Squamata: Iguanidae: Dactyloinae), in South America

Luis Amador<sup>1, 2, 6</sup>, Fernando Ayala-Varela<sup>3</sup>, Andrea E. Nárvaez<sup>3, 4</sup>, Keyko Cruz<sup>5</sup> & Omar Torres-Carvajal<sup>3</sup>

<sup>1</sup>Universidad Austral de Chile, Instituto de Ciencias Ambientales y Evolutivas, Facultad de Ciencias, campus Isla Teja, Valdivia, Chile

<sup>2</sup>Universidad Laica Vicente Rocafuerte, Avenida de Las Américas, 11-33, Guayaquil, Ecuador

<sup>3</sup>Pontificia Universidad Católica del Ecuador, Museo de Zoología, Escuela de Ciencias Biológicas, Av. 12 de Octubre y Roca, Apartado 17-01-2184, Quito, Ecuador

<sup>4</sup>La Trobe University, Department of Ecology, Environment and Evolution, Bundoora VIC 3086, Australia

<sup>5</sup>Universidad de Guayaquil, Facultad de Ciencias Naturales, Escuela de Biología, Guayaquil, Ecuador

<sup>6</sup>Corresponding author. E-mail: amadoroyola@gmail.com

**Abstract:** We report the first record of the invasive Brown Anole, *Anolis sagrei* Duméril & Bibron, 1837, in South America based on nine specimens from Samborondón, Guayas province, Ecuador. We also present some information related to the current distribution in Ecuador, and its possible impacts on native lizard species.

**Key words:** Ecuador; introduced species; Guayas; lizards; distribution; urban areas; range extension

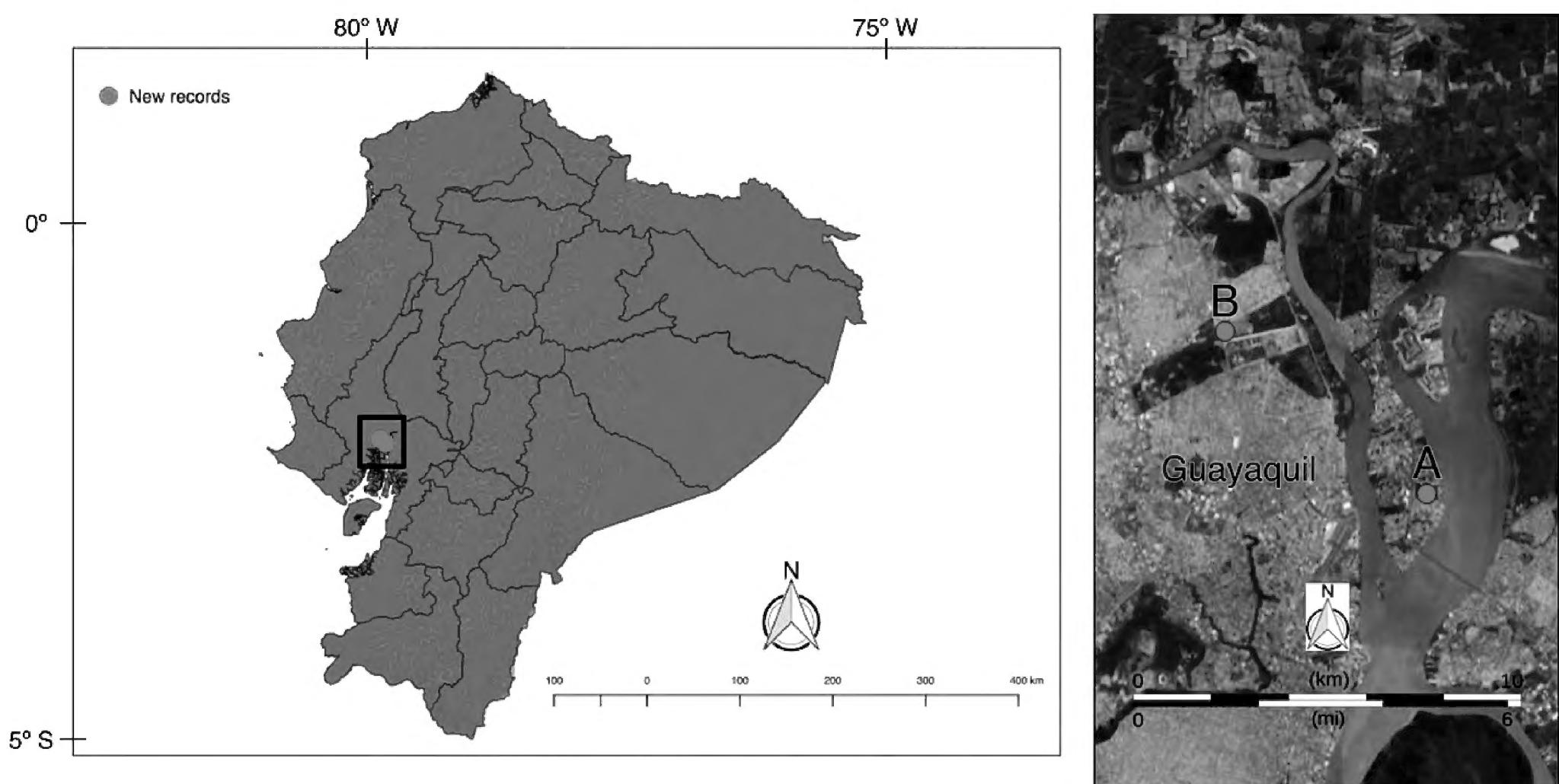
Introduced species are known to be potentially harmful and cause negative effects on native species and ecosystems. In addition, economic losses are common because of the occurrence and persistence of introduced species (PIMENTEL et al. 2001). Events of species introduction constitute one of the main drivers of biodiversity loss (CHAPIN et al. 2000; DIDHAM et al. 2005). In some cases, non-native species constitute the cause for local or global changes in abundance, and of species composition (KRAUS 2015; NUÑEZ & PAUCHARD 2010). Thus, it becomes a big challenge to counteract the advance of introduced species, especially in megadiverse countries that are undergoing intensive economic development (LÖVEI et al. 2012). Despite the exceptional biodiversity of South America (MYERS et al. 2000), not many developing South American countries have dedicated sufficient research resources to investigate non-native species and the impact of them on local ecosystems and its biodiversity (SPEZIALE et al. 2012). Examples of introduced species that have caused serious impacts on the native biodiversity of South America are North American Beaver (*Castor canadensis*) in Chile and Argentina [see WALLEM et al. (2007) and ANDERSON et al. (2009)], Chinook Salmon, *Oncorhynchus tshawytscha* in Chile [CORREA & GROSS (2007)], and Red Swamp Crayfish,

*Procambarus clarkii* in Brazil, Colombia, Ecuador, and Venezuela [LOUREIRO et al. (2015)].

The number of introduced species of amphibians and reptiles in the continental part of the Americas is small; these introductions have been caused mostly by human actions and cause biodiversity loss. An example is introduced populations of American Bullfrog, *Lithobates catesbeianus*, in many countries of Central and South America for the purpose of breeding on farms and trading the meat (see VALAREZO-AGUILAR et al. 2016). *Lithobates catesbeianus* is well known for its large size and voracious appetite, and preys on several native species, displacing even other amphibian native species (LAUFER et al. 2008; AKMENTINS et al. 2009). Other examples of introduced species of herpetofauna were analyzed by HEGAN (2014) (e.g., Burmese Python, *Python bivittatus*; Cuban Brown Anole, *Anolis sagrei*; Cuban Tree-frog, *Osteopilus septentrionalis*; Green Iguana, *Iguana iguana*; Mediterranean House Gecko, *Hemidactylus turcicus*; and Nile Monitor, *Varanus niloticus*). Nevertheless, the impacts of these introductions have been mainly on native species of flora and fauna, displacing or predating them.

At a global scale, several lizard species of the genus *Anolis* have been found, reported and studied in hundreds of places outside their natural range (e.g., NICHOLSON & RICHARDS 2011; STUART et al. 2012; NORVAL et al. 2014; YASUMIBA et al. 2016). For example, the Cuban *Anolis porcatus* was reported recently by SAMELO & BARRELA (2016) in São Paulo state, Brazil. PRATES et al. (2016) realized its molecular identification and geographic origin and suggested that *A. porcatus* reached Brazil unintentionally via transportation on ships.

A classic successful example of a non-native species of *Anolis* is the case of *A. sagrei*. DUMÉRIL & BIBRON (1837) described *A. sagrei* from its original location “Cuba”. Its



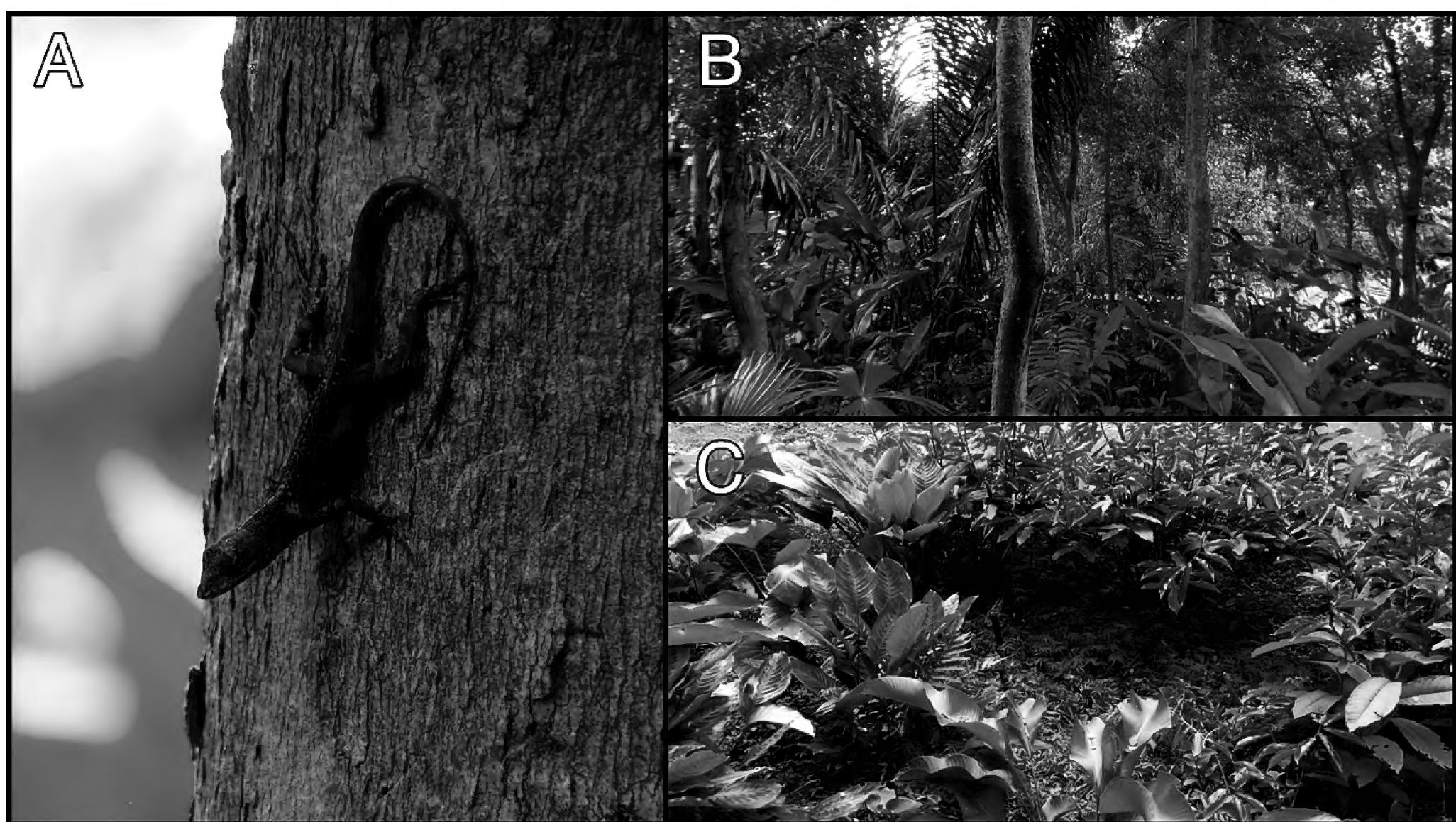
**Figure 1.** Distribution of *Anolis sagrei* in Ecuador (red circles). The box shows the two new records in Guayas province. **A.** Parque Histórico de Guayaquil (PHG). **B.** El Cóndor town, near Parque Samanes.

native range also includes the Bahamas, the Caribbean coast of Mexico (Losos J.B. personal communication), Little Cayman, Cayman Brac, other adjacent little cays, and satellite islands in the Caribbean. This species, commonly known as the Brown Anole, was recognized as an invasive species in 1887, when it was found in Florida, USA (GRANATOSKY & KRYSKO 2013). It is currently reported in 12 other states in that country, including the mid-Pacific state of Hawaii (MAUTZ & SHAFFER 2011; GRANATOSKY & KRYSKO 2013). In Central America, the Brown Anole has also invaded the Mexican interior, Belize, Bermuda and several Caribbean islands such as Grand Cayman, Grenada, Turks and Caicos and Anguilla (GREENE et al. 2002; KOLBE et al. 2004; BURGESS 2012; WILLIAMS & CARTER 2015; STROUD et al. 2017). Introductions in Jamaica could have been mediated by humans (BURGESS 2012). However, this assumption remains unclear. Furthermore, *A. sagrei* is introduced to Asia, where it is known from Taiwan (NORVAL et al. 2002), and more recently, Singapore (TAN & LIM 2012).

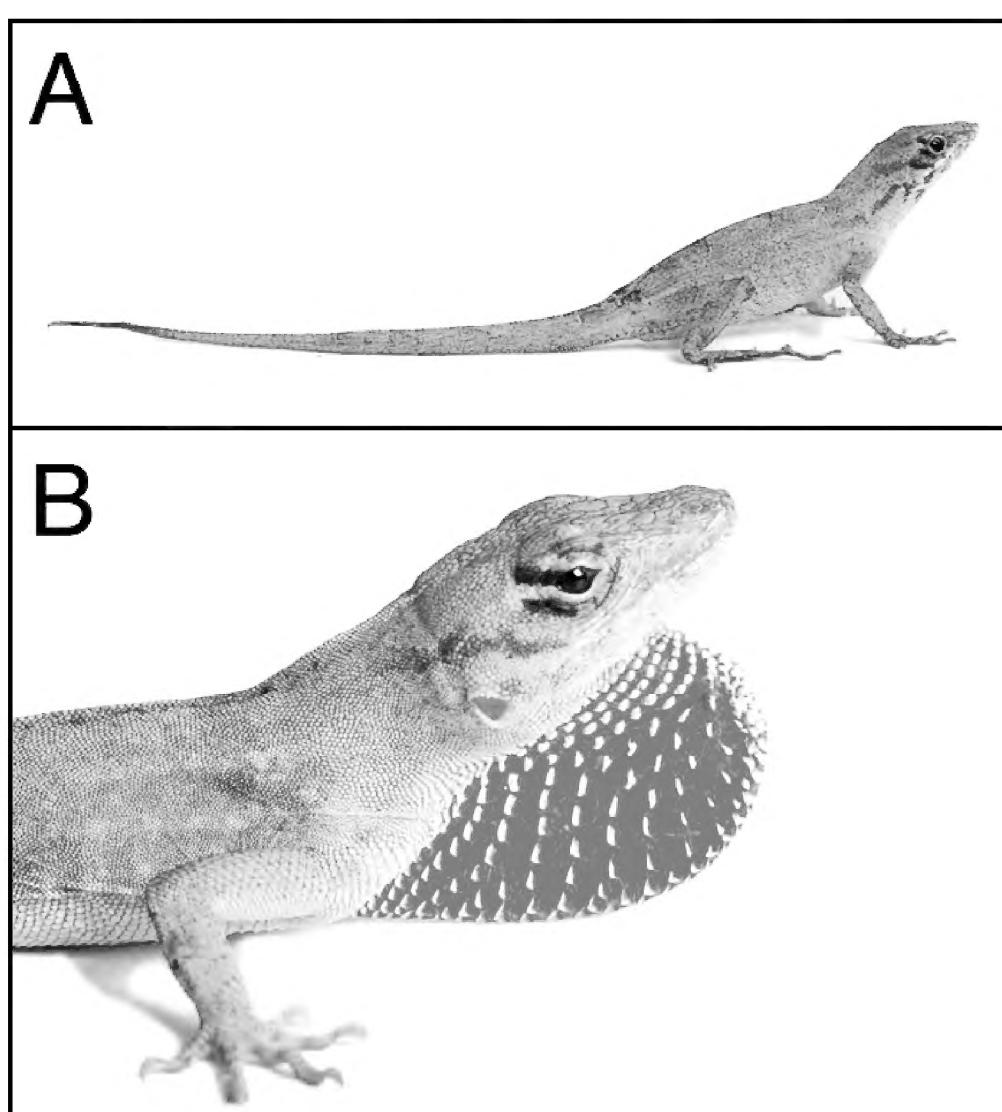
Previous phylogenetic studies on introduced and native populations of *A. sagrei* have shown that several dispersal events between native localities and invaded areas are possible (KOLBE et al. 2004; KOLBE et al. 2008). These events are caused mainly by anthropogenic activities, such as the pet trade, ornamental plant trade, and tourism (POWELL et al. 2011; TAN & LIM 2012). Herein, we report for the first time the occurrence of *A. sagrei* in South America, based on records from Ecuador. It is noteworthy that this record is the first in the southern hemisphere. All previous records were reported in the Tropical Atlantic and Central/Eastern Indo-Pacific area, including natural localities and the invaded areas (NORVAL et al. 2002; MAUTZ & SHAFFER 2011; TOSCANO-FLORES & CALZADA-ARCINIEGA 2015; WILLIAMS & CARTER 2015).

We collected individuals of Brown Anoles at Parque Histórico de Guayaquil (PHG) (Figure 1), a recreational tourism park in an urban area of Samborondón, province of Guayas ( $02^{\circ}08'39"S$ ,  $079^{\circ}52'12"W$ , 7 m). It is managed by the central government of Ecuador. On 18 December 2015 during a 1-hour survey (10:30–11:30 h), we observed 25 individuals (males, females, juveniles and neonates) within an area of  $16\text{ m}^2$  at PHG. Of these, six individuals were collected, two adult females (QCAZ 14296-97; Figure 3) and four juvenile specimens (QCAZ 14298-99, 14300-01), which were found perching at a height of 0.5–1.5 m on herbaceous plant species and on big trees such as *Triplaris cumingiana* at a height of 2–4 m (Figure 2). On 11 February 2016 (10:00–12:00 h) two additional specimens were collected, one subadult female (QCAZR 14489) and one juvenile male (QCAZR 14490) from the same area and with similar activity as the six previously mentioned individuals. All specimens were found in a garden that surrounds an artificial island, and along streets near PHG. The garden vegetation was dominated by a mixture of native species with introduced species of herbaceous and ornamental plants, mostly *Calathea* sp., *Crinum* sp., *Alpinia* sp., *Anthurium* spp., which do not represent any natural ecosystem. On 11 February 2016, one adult male (QCAZR 14488; Figure 3) was collected from a ficus tree (*Ficus benjamina*) on the street 495 m away from the locality at PHG. Two additional individuals (not collected) were found inside a house near “Parque Samanes” in northern Guayaquil ( $02^{\circ}06'41"S$ ,  $079^{\circ}54'24"W$ , 10 m) 5.5 km in a straight line from PHG. The specimens were collected under permit 003-15 IC-FAU-DNB/MA and were deposited at Museo de Zoología (QCAZ), Pontificia Universidad Católica del Ecuador.

We also observed that males of *A. sagrei* in PHG extended their dewlap, which may suggest that males had estab-



**Figure 2.** Habitat where *Anolis sagrei* was found in the Parque Histórico de Guayaquil, Samborondón, Guayas province, Ecuador. **A.** Individual of *A. sagrei* not collected. **B.** Habitat of native and non-native large trees. **C.** Habitat of native and non-native herbaceous and ornamental plants.



**Figure 3.** Two individuals of *Anolis sagrei* found in Guayas province, Ecuador. Adult female QCAZ 14296 (**A**), adult male QCAZ 14488 (**B**). Photos: Fernando Ayala and Valeria Chasiluisa.

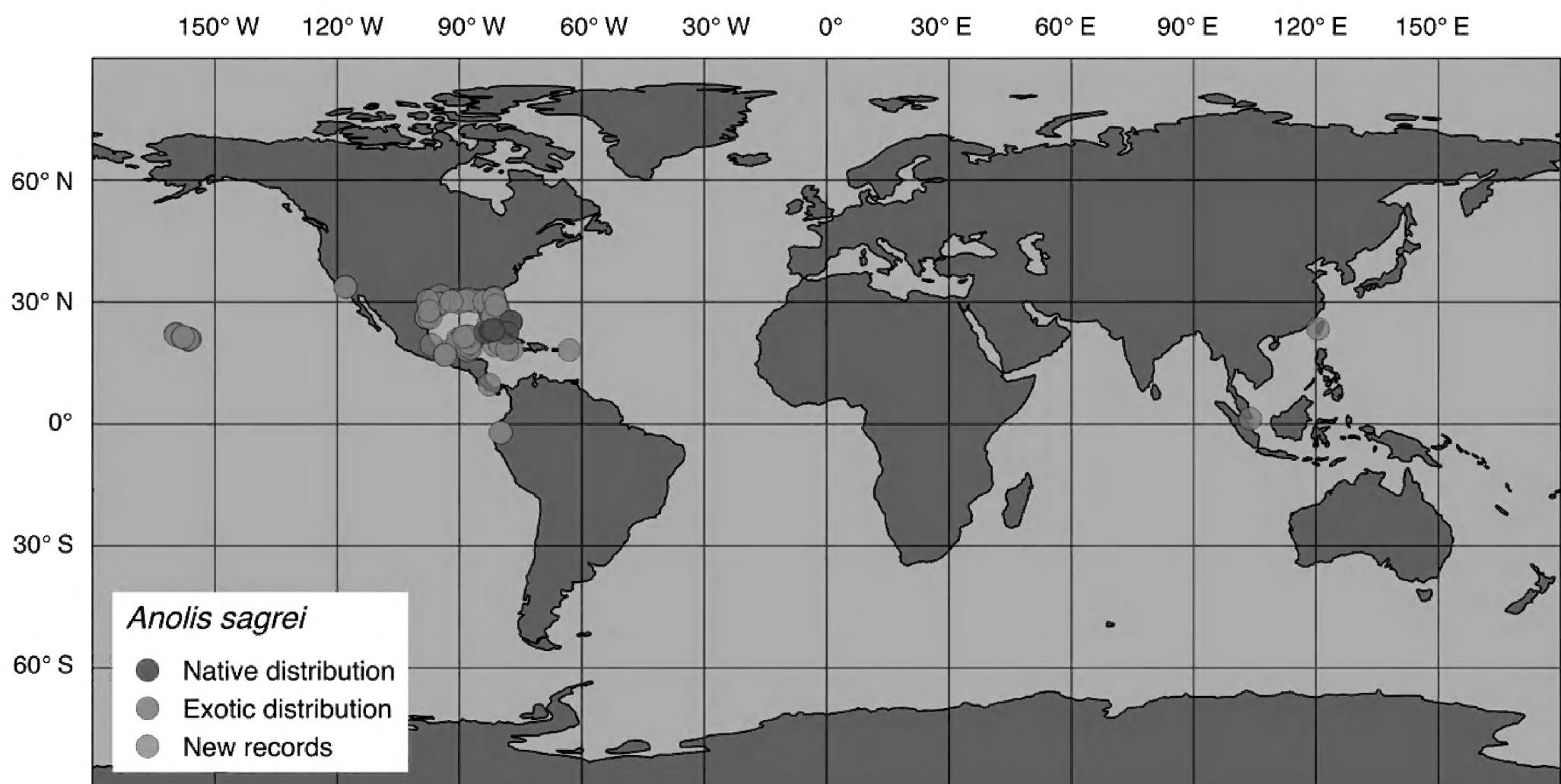
lished territories.

**New record report.** Occurrence records (total 140) of *A. sagrei*, were obtained from the Global Biodiversity Information Facility (GBIF) and are presented in Figure 4,

including our new records.

**Morphological characterization.** The external character terminology follows standards established by WILLIAMS et al. (1995) and POE & YAÑEZ-MIRANDA (2008). Lamellar number was counted only on phalanges III and IV of the fourth toe; measurements were made with digital calipers on live specimens and are given in millimeters (mm) usually to the nearest 0.1 mm. Snout-vent length (SVL) was measured from the tip of the snout to the anterior edge of the cloaca (Table 1).

The collected specimens were examined and photographed. We compared the morphological characteristics of our specimens with information reported by POE (2004); NICHOLSON et al. (2007); LOSOS (2009) & NICHOLSON et al. (2012) to confirm that our specimens fall into the diagnostic characteristics of *A. sagrei*. The males of *A. sagrei* are characterized by having a red-orange dewlap, sometimes with a yellow border or blotches. Females often have a dorsal pattern with diamonds, bars, or a stripe running down their back. Brown Anoles do not have a light ring around the eye or a light stripe above the front limb. Instead, they often have two dark bars above their eyes (KOLBE et al. 2014). *Anolis sagrei* is easily distinguished by a laterally compressed tail (tail rounded or slightly rounded in Ecuadorian species). The Ecuadorian specimens presented the following characteristics (Table 1): small body size (males QCAZ 14488, 14490 with snout-vent length (SVL) = 38.6–54.2 mm; females QCAZ 14296, 14297, 14489 with SVL = 42.3–43.4 mm), moderately robust, a short snout, and a long tail and claws. The dewlap of our specimens was orange



**Figure 4.** World map showing the locations currently known of *Anolis sagrei*. Green spots correspond to the native area, yellow spots are the non-native distribution, and the red spots corresponds to the new records reported here.

or red with yellow edges and white scales. The vent was light yellowish cream. They showed variable dorsal coloration, from a grayish-brown background with light and dark spots all over the body to an almost black background. The spots are more apparent on the face, forming dark bands on the eyes. Some specimens changed their dorsal color between grayish-brown and almost black after a few minutes of being captured. Some individuals also have a light medium dorsal line. This diagnosis agrees with the morphology presented in other areas of the native range, and with areas where the species has been introduced (NORVAL et al. 2002; TAN & LIM 2012). However, the number of lamellae in the fourth toe is higher than other localities (35–37, Table A1). Steven Poe from the Department of Biology at the University of New Mexico confirmed the identity of the specimens.

*Anolis sagrei* is the fourth species of non-native lizard successfully introduced in continental Ecuador. The three previous species correspond to two Asian geckos, *Lepidodactylus lugubris* and *Hemidactylus frenatus* (JADIN et al. 2009), and one African gecko, *Hemidactylus mabouia* (CARVAJAL-CAMPOS & TORRES-CARVAJAL 2010). We observed male and female adults, juveniles and neonates of *A. sagrei*; therefore, we conclude that there is already a well-established population in the PHG, and that this species is utilizing non-native vegetation (*Ficus* spp.) at the urban area of Samborondón, Guayas.

The specimens reported here were not found in sympatry with other native lizard species. However, this area seems suitable for the occurrence of diurnal species such as *Iguana iguana* and *Gonatodes caudiscutatus*, the nocturnal species *Phyllodactylus reissii*, and the introduced gecko *Lepidodactylus lugubris*. It is very likely that *A. sagrei* would compete with them for resources. Further observations

are needed to know if other anole species are present in the PHG, and whether *A. sagrei* influences the structure of communities.

We still do not know the geographic origin, the mean of transportation, or the colonization time of this population of *A. sagrei*. Nevertheless, we hypothesize that the lizards could have come on ships from the Caribbean Sea that cross through the Panama Canal (see e.g. MUIRHEAD et al. 2015). Molecular studies would be useful to determine the origin of Brown Anoles from Ecuador.

We recommend establishing a monitoring program of the population of Brown Anoles here reported, as well as potential introduction events, which could account for a genetically diverse biological invasion (KOLBE et al. 2004). Management and education measures are necessary to achieve the goal of minimizing the impacts of this invasion and to prevent further colonization. Eradication programs and control attempts through the extermination of well-established populations of invasive *Anolis* are a significant challenge. Such attempts have failed in Japan and in Taiwan for *Anolis carolinensis* and *A. sagrei* respectively, sometimes with severe damage to native lizard species (ISHIKAWA et al. 2012; PRATES et al. 2016). Although the possible impacts of *A. sagrei* on the environment in Ecuador are still unknown, the fact that the Brown Anole is near areas of dense vegetation and forests means it is necessary to properly monitor *A. sagrei* and its possible dispersal and effects on native fauna.

## ACKNOWLEDGEMENTS

We would like to thank Steven Poe, who verified the identity of the specimens of *Anolis* reported here; Rafaela

**Table 1.** Scalation and morphometric comparison of *Anolis sagrei* from different localities around the world (NORVAL et. al 2002). SVL max = maximum snout-vent length.

Locality	Mexico (Yucatan)	Cuba (Cardenao and Kabana)	Honduras (San Pedro Sula)	Taiwan (Chiayi)	Ecuador (Guayaquil)
Sex	♂	♀	♂	♀	♀
Sample	1	4	1	15	2
Interorbital scales	1	0-2	2	1	1-2
Inteparietal/Interorbital scales	3-4	2-3	3	3	2-3
Loreal rows	4	4-5	4	2-3	2-4
Supralabials	5-6	4-6	5	4-5	4-5
Scales between second canthals	7	5-6	6	4-5	4-5
Internasal scales	7	5-7	6	6	5-6
Lamellae 4th. toe	33	29-33	31	32	35-37
Dorsal scales in 5 mm	17	10-16	19	11	11-17
Ventral scales in 5 mm	13	9-12	13	9	11-15
Head length	12.2	11.2-16.2	10.7	12.7	10.0-11.9
Tibia length	10.2	9.5-16.7	9.2	12.1	7.7-10.5
SVL	41.2	38.8-62.7	38.2	59.4	48.1
					34.9-44.0
					47.0-62.1
					38.6-54.2
					42.3-43.4

Orrantia, Jessica Zambrano, Geovanny Zambrano and the Empresa Pública de Parques Urbanos y Espacios Públicos granted access to sampling areas; Xavier Cornejo, Herbario GUAY (Universidad de Guayaquil) helped with the identification of several plant species. Jonathan Losos provided information about *Anolis sagrei* distribution in the Caribbean Sea. We are grateful to two anonymous reviewers for providing comments that greatly improved the final version of the manuscript. Nicole Butler provided helpful comments to latest versions of the manuscript. LA wants to thank the Secretaría Nacional de Educación Superior, Ciencia, Tecnología e Innovación (SENESCYT) for the scholarship. Thanks to Mayra García for management and help in the field, Valeria Chasiluisa for one of the photographs of *A. sagrei* in the lab and Estefania Guerra for editing some pictures.

## LITERATURE CITED

AKMENTINS, M.S., L.C. PEREYRA & J.N. LESCANO. 2009. Primer registro de una población asilvestrada de rana toro (*Lithobates catesbeianus*) en la Provincia de Córdoba, Argentina. Notas sobre la biología de la especie. Cuadernos de Herpetología 23(1): 25-32.

ANDERSON, C.B., G.M. PASTUR, M.V. LENCINAS, P.K. WALLEM, M.C. MOORMAN & A.D. ROSEMOND. 2009. Do introduced North American Beavers *Castor canadensis* engineer differently in southern South America? An overview with implications for restoration. Mammal Review 39: 33-52. doi: <http://doi.org/d73dts>

BURGESS, J. 2012. Cuban brown anoles (*Anolis sagrei*) in the Turks and Caicos Islands. IRCF Reptiles & Amphibians 19(4): 263-264.

CARVAJAL-CAMPOS, A. & O. TORRES-CARVAJAL. 2010. *Hemidactylus mabouia* Moreau De Jonnès, 1818 and *H. frenatus* Schlegel, 1836 in western Ecuador: new records reveal range extension. Herpetozoa 23(1/2): 90-91.

CHAPIN III, F.S., E.S. ZAVALETA, V.T. EVINER, R.L. NAYLOR, P.M. VITOUSEK, H.L. REYNOLDS, D.U. HOOPER, S. LAVOREL, O.E. SALA, S.E. HOBBIE, M.C. MACK & S. DÍAZ. 2000. Consequences of changing biodiversity. Nature 405: 234-242. doi: 10.1038/35012241

CORREA, C. & M.R. GROSS. 2007. Chinook Salmon invade southern South America. Biological Invasions 10(5): 615-639. doi: <https://doi.org/10.1007/s10530-007-9157-2>

DIDHAM, R.K., J.M. TYLIANAKIS, M.A. HUTCHISON, R.M. EWERS & N.J. GEMMELL. 2005. Are invasive species the drivers of ecological change? Trends in Ecology and Evolution 20(9): 470-474. doi: 10.1016/j.tree.2005.07.006

DUMÉRIL, A.M.C. & G. BIBRON. 1837. Erpétologie général ou histoire naturelle complète des reptiles, Vol. 4. Paris: Roret. 571 pp.

GRANATOSKY, M.C. & K.L. KRYSKO. 2013. The Brown Anole, *Anolis sagrei* Duméril and Bibron 1837 (Dactyloidae), state record and introduction pathway. IRCF Reptiles & Amphibians 20(4): 190-191.

GREENE, B.T., D.T. YORKS, J.S. PARMERLEE, JR., R. POWELL & R.W. HENDERSON. 2002. Discovery of *Anolis sagrei* in Grenada with comments on its potential impact on native anoles. Caribbean Journal of Science 38(3-4): 270-272.

HEGAN, A.E. 2014. Alien herpetofauna pathways, invasions, current management practices and control method ethics: a review of some significant problems in the USA. The Herpetological Bulletin 129: 3-14.

ISHIKAWA T., S. ABE, N. HASEGAWA, K. TAKAYANAGI, M. MIHARA & O. ARAKAWA. 2012. Control of nonnative green anole *Anolis carolinensis* using adhesive traps and impact assessment of unintentional captures of small vertebrates in the southern part of Okinawajima

Island, Japan. Biological Magazine Okinawa 50: 37–47.

JADIN, R.C., M.A. ALTAMIRANO, M.H. YÁNEZ-MUÑOZ & E.N. SMITH. 2009. First record of the Common House Gecko (*Hemidactylus frenatus*) in Ecuador. Applied Herpetology 6: 193–195.

KRAUS, F. 2015. Impacts from invasive reptiles and amphibians. Annual Reviews of Ecology, Evolution, and Systematics 46: 75–97. doi: 10.1146/annurev-ecolsys-112414-054450

KOLBE, J.J., R.E. GLOR, L. RODRÍGUEZ SCHETTINO, A. CHAMIZO LARA, A. LARSON & J.B. LOSOS. 2004. Genetic variation increases during biological invasion by a Cuban lizard. Nature 431: 177–181. doi: 10.1038/nature02807

KOLBE, J.J., A. LARSON, J.B. LOSOS & K. DE QUEIROZ. 2008. Admixture determines genetic diversity and population differentiation in the biological invasion of a lizard species. Biology Letters 4: 434–437. doi: 10.1098/rsbl.2008.0205

KOLBE, J.J., K.J. FEELEY, A. BATTLES & J.T. STROUD. 2014. Field identification guide for the anole lizards of Miami. Coral Gables, Florida: The Fairchild Challenge.

LAUFER, G., A. CANAVERO, D. NÚÑEZ & R. MANEYRO. 2008. Bullfrog (*Lithobates catesbeianus*) invasion in Uruguay. Biological Invasions 10: 1183–1189. doi: 10.1007/s10530-007-9178-x

LOSOS, J.B. 2009. Lizards in an evolutionary tree: ecology and adaptive radiation of anoles. Berkeley: University of California Press. 527 pp.

LOUREIRO, T.C., P.M. ANASTÁCIO, P.B. ARAUJO, C. SOUTY-GROSSET & M.P. ALMERÃO. 2015. Red swamp crayfish: biology, ecology and invasion - an overview. Nauplius 23(1): 1–19. doi: 10.1590/S0104-64972014002214

LÖVEI, G.L., T.M. LEWINSOHN & THE BIOLOGICAL INVASIONS IN MEGADIVERSE REGIONS NETWORK. 2012. Megadiverse developing countries face huge risks from invasives. Trends in Ecology and Evolution 27(1): 2–3. doi: 10.1016/j.tree.2011.10.009

MAUTZ, W.J. & H.B. SHAFFER. 2011. Colonization of Hawaii island by the Brown Anole (*Anolis sagrei*). Herpetological Review 42(4): 508–509.

MUIRHEAD, J.R., M.S. MINTON, W.A. MILLER & G.M. RUIZ. 2015. Projected effects of the Panama Canal expansion on shipping traffic and biological invasions. Diversity and Distributions 21: 75–87. doi: 10.1111/ddi.12260

MYERS, N., R.A. MITTERMEIER, C.G. MITTERMEIER, G.A.B. DA FONSECA & J. KENT. 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853–858.

NICHOLSON, K.E., L.J. HARMON & J.B. LOSOS. 2007. Evolution of *Anolis* Lizard Dewlap Diversity. PLoS ONE 2(3): e274. doi: <https://doi.org/10.1371/journal.pone.0000274>

NICHOLSON, K.E. & P.M. RICHARDS. 2011. Home-range size and overlap within an introduced population of the Cuban Knight Anole, *Anolis equestris* (Squamata: Iguanidae). Phyllomedusa 10(1): 65–73.

NICHOLSON, K.E., B.I. CROTHER, C. GUYER & J.M. SAVAGE. 2012. It is time for a new classification of anoles (Squamata: Dactyloidae). Zootaxa 3477: 1–108.

NORVAL, G., J.J. MAO, H.P. CHU & L.C. CHEN. 2002. A new record of an introduced species, the Brown Anole (*Anolis sagrei*) (Duméril & Bibron, 1837), in Taiwan. Zoological Studies 41(3): 332–336.

NORVAL, G., S.C. HUANG & J.J. MAO. 2014. Notes on the growth rates of *Anolis sagrei* Duméril and Bibron, 1837 from a small Betelnut Palm (*Areca catechu*, L.) plantation in southwestern Taiwan. IRCP Reptiles & Amphibians 21(1): 9–15.

NUÑEZ, M.A. & A. PAUCHARD. 2010. Biological invasions in developing and developed countries: does one model fit all? Biological Invasions 12: 707–714. doi: 10.1007/s10530-009-9517-1

PIMENTEL, D., S. MCNAIR, J. JANECKA, J. WIGHTMAN, C. SIMMONDS, C. O'CONNELL, E. WONG, L. RUSSEL, J. ZERN, T. AQUINO & T. TSOMONDO. 2001. Economic and environmental threats of alien plant, animal, and microbe invasions. Agriculture, Ecosystems and Environment 84: 1–20.

POB, S. 2004. Phylogeny of anoles. Herpetological Monographs 18: 37–89.

POE, S. & C. YAÑEZ-MIRANDA. 2008. Another new species of green *Anolis* (Squamata: Iguanidae) from the Eastern Andes of Peru. Journal of Herpetology 42 (3): 564–571.

POWELL, R., R.W. HENDERSON, M.C. FARMER, M. BREUIL, A.C. ECHTERNACHT, G. VAN BUURT, C.M. ROMAGOSA & G. PERRY. 2011. Introduced amphibians and reptiles in the greater Caribbean: patterns and conservation implications; pp. 63–143, in: A. HAILEY, B.S. WILSON, B. S. & J.A. HORROCKS (eds.). Conservation of Caribbean island herpetofaunas, Volume 1: Conservation biology and the wider Caribbean. Leiden: Brill.

PRATES, I., L. HERNANDEZ, R.R. SAMELO & A.C. CARNAVAL. 2016. Molecular Identification and geographic origin of an exotic anole lizard introduced to Brazil, with remarks on its natural history. South American Journal of Herpetology 11(3): 220–227. doi: <https://doi.org/10.2994/SAJH-D-16-00042.1>

SAMELO, R.R. & W. BARRELLA. 2016. Geographic distribution: *Anolis porcatus* (Cuban Green Anole). Herpetological Review 47(2): 256.

SPEZIALE, K.L., S.A. LAMBERTUCCI, M. CARRETE & J.L. TELLA. 2012. Dealing with non-native species: what makes the difference in South America? Biological Invasions 14: 1609–1621. doi: 10.1007/s10530-011-0162-0

STROUD, J.T., S.T. GIERY, & M.E. OUTERBRIDGE. 2017. Establishment of *Anolis sagrei* on Bermuda represents a novel ecological threat to Critically Endangered Bermuda skinks (*Plestiodon longirostris*). Biological Invasions [advance access]. doi: 10.1007/s10530-017-1389-1

STUART, Y.E., M.A. LANDESTOY, D.L. MAHLER, D. SCANTLEBURY, A.J. GENEVA, P.S. VANMIDDLESWORTH & R.E. GLOR. 2012. Two new introduced populations of the Cuban green anole (*Anolis porcatus*) in the Dominican Republic. IRCP Reptiles & Amphibians 19(1): 71–75.

TAN, H.H. & K.K.P. LIM. 2012. Recent introduction of the brown anole *Norops sagrei* (Reptilia: Squamata: Dactyloidae) to Singapore. Nature in Singapore 5: 359–362.

TOSCANO-FLORES, C. & R.A. CALZADA-ARCINIEGA. 2015. Geographic distribution: *Anolis sagrei* (Brown Anole). Herpetological Review 46(2): 215.

VALAREZO-AGUILAR, K., D.F. CISNEROS-HEREDIA & O. ORDOÑEZ-GUTIERREZ. 2016. A new distribution record for the invasive American Bullfrog, *Lithobates catesbeianus* (Shaw 1802) (Anura: Ranidae), from eastern Ecuador. IRCP Reptiles & Amphibians 23(2): 147–149.

WALLEM, P.K., C.G. JONES, P.A. MARQUET & F.M. JAKSIC. 2007. Identifying the mechanisms underlying the invasion of *Castor canadensis* (Rodentia) into Tierra del Fuego archipelago, Chile. Revista Chilena de Historia Natural 80: 309–325.

WILLIAMS, E.E., H. RAND, A.S. RAND & R.J. O'HARA. 1995. A computer approach to the comparison and identification of species in difficult taxonomic groups. Breviora 502: 1–47.

WILLIAMS, R.J. & D. CARTER. 2015. Cuban Brown Anoles (*Anolis sagrei*) in Anguilla. IRCP Reptiles & Amphibians 22(4): 182–183.

YASUMIBA, K., A. OKADA, I. OKOCHI & N. IWAI. 2016. Minimum Longevity and Growth of the Invasive Green Anole, *Anolis carolinensis*, in Chichi-jima of the Ogasawara Islands, Japan. Current Herpetology 35(2): 101–105. doi: 10.5358/hsj.35.101

**Authors' contributions:** LA and KC collected the data, LA, FAV and OTC identified the specimens, LA, FAV, AEN and OTC wrote the text.

**Received:** 8 September 2016

**Accepted:** 22 March 2017

**Academic editor:** Rafael Fraga